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STATE OF ILLINOIS

DWIGHT H. GREEN, Governor

TEMPERATURE AND TURBIDITY OF SOME RIVER WATERS IN ILLINOIS

By

MAX SUTER

Issued by

DEPARTMENT OF REGISTRATION AND EDUCATION

FRANK G. THOMPSON, Director

STATE WATER SURVEY DIVISION

A. M. BUSWELL, Chief

URBANA, ILLINOIS

1948

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Max Suter [1]

Illinois vater supplies come from two sources: ground waters from veils; and surface waters from streams and lakes. The choice between these two sources is made principally on the basis of availability and economy. Many factors, however, enter into such considerations. The State Water Survey is mainly interested in the hydrologic phases of the problems involved in selecting a water supply. These may be classified in two groups: 1) The quantity of water available; 2) the quality of water available.

Considerations governing quantity:

The availability of ground water supplies is limited in many cases by the factor of safe yield, that is, by the extent to which the well can be pumped continuously. If this yield is exceeded, a lowering in the non-pumping water levels occurs. This recession increases with time, and although it does not take place at a constant rate, and from time to time there may even be a temporary rise in the non-pumping level, the general trend is downward. Wherever such a recession is found to exist, steps should be taken to eliminate the overdraft on the well field, either by increasing infiltration or by using some surface water in place of ground water, or by both methods.

Considerations governing quality

In applying these methods, the quality of the surface waters available is important. Chemical and sanitary qualities, although of great importance,

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1 Engineer, Illinois State Water Survey

are not discussed here. This paper is limited to a study of two physical qualities, temperature and turbidity, of some of the principal streams in Illinois which are Important from the standpoint of surface water supply.

Ground vater is generally preferred for cooling purposes in Industrial processes because of its lower temperature and greater freedom from sediment. Therefore, wherever surface waters are used for recharge by means of infiltration or for the replacement of ground water, the properties of temperature and turbidity are of prime importance.

Source of Data

Data on the Ohio, Illinois and the Mississippi Fivers have been obtained at the following places with the assistance of the persons named:

Moline: Mr. A. E. Anderson, Superintendent of the Moline Water Works, for the period 1935-45 inclusive.

Quincy: Mr. W. R. Gelston, Superintendent, Water Works Commission, for the period 1929-45 inclusive.

Alton: Mr. F. H. King, Manager, Alton Water Company, for the period 1936-45 Inclusive.

East St. Louis: Mr. C. M. Boos, Manager, East St. Louis and Interurban Water Company, for the period 1937-1945 inclusive.

Cairo: Mr. E. L. Hileman, Manager, Cairo Water Co., for the period 1936-1945 inclusive.

Peoria: Office of the Sanitary District of Chicago, for the period 1935-45 inclusive.

Data on the Missouri River for the period 1935-45 inclusive have been received from Mr. Charles Elbreder of the St. Louis County Water Company. Although these data come from outside the State of Illinois, they are

lncluded in Table 1 and 2 because they give an indication of the reason for the changes which take place between Alton and East St. Louis, between which points the Missouri enters the Mississippi. The Missouri has a watershed of 520,000 square miles, as compared with the Mississippi's 180,000 square miles at the Junction of the two rivers.

Treatment of Data

The data used are records of daily measurements of temperatures and turbidity, made by the respective waterworks operators on the raw water pumped from the river, in conformity with Standard Methods for the Examination of Water and Sewage, published by the American Public Health Association. These data were plotted to ascertain the duration in days per year of each unit measured. The duration of each of these periods, determined for each calendar year, was averaged and the upper and lower limits noted.

Table I summarizes the temperature data determined in this manner, and Table 2, the turbidity data. Plate 1 shows these data graphically.

It should be noted that although the maximum and minimum data given are the limits found for each station, these do not necessarily occur in the same year. The curves for maximum and minimum are, therefore, not actual occurrence curves, but envelope curves of the limiting cases within the period measured.

In order to obtain fairly representative data, daily observations should cover a period of at least 10 years, and it is fortunate that this great body of material was available for this study.

The data on temperature and turbidity indicate the periods during which each of these factors is present at each point of observation. In practical utilization of river water it is often important to know the periods when certain conditions of temperature and turbidity exist simultaneously. This information has been obtained by superimposing the

curves for temperature and turbidity in such a way as to secure the desired combination, then counting the number of days when both conditions occurred simultaneously. This was done, however, only for temperatures within a range of 55°F. to 70°F. and for turbidities up to 200 ppm. These ranges were chosen because they were believed to represent the upper limits of usability of the water. Table 3 and Plates 2 and 3 show the data obtained.

Trend along River

The data presented so far are for the individual stations from which records were available. It was, however, possible to determine the trend along the Mississippi River from Moline to East St. Louis. This trend is indicated on Plate 4 by curves in which the averages of the periods for which certain temperatures or turbidities exist are plotted as ordinates and the river distances as determined by the U.S. Engineers, as abscissas. The graphs show the entire length of the Mississippi bordering the State of Illinois, but the data curves cover only that part of the river for which records are available. Columns are added to these curves to show, for comparative purposes, the corresponding data for the Illinois River at Peoria and the Ohio River at Cairo.

These graphs show that the temperature of the Mississippi River water rises as the river flows south, which is to be expected. The slope of the curve, however, indicates that there is a progressive decrease in the period of duration of a given temperature amounting to about 8 days for each 100 miles of river length. The average temperature of Mississippi River water increases about 1 l/2°F. over the same distance. Sharp changes in the temperature rates are caused by the inflow of the Missouri River. It is also interesting to note that the temperature of the Illinois River at Peoria corresponds to the temperature of the Mlssippi River above Moline

in summer and below Quincy In winter. The Ohio River at Cairo is colder in summer and warmer in winter than the Mississippi River at East St. Louis.

The turbidity of the Mississippi River increases as the river flows south. This increase is especially marked in the periods of low turbidity, which are considerably reduced in length. The Missouri River Increases the turbidity of the Mississippi, especially during periods of high turbidity. It must be noted, however, that the intake of the East St. Louis plant is on the Illinois side only two miles below the mouth of the Missouri River, and therefore, especially during the relatively clear low-flow periods, the two waters do not mix completely and the clearer water of the Mississippi predominates at the intake. Periods of low turbidity are shorter in the Ohio River at Cairo than they are in the Mississippi at East St. Louis, and the periods of high turbidity are slightly longer. This indicates that higher turbidities exist in the Ohio River than in the Mississippi. This is in contradiction to reports made by aviators, who state that the Ohio River side below the junction of the two rivers looks blue for a long distance as compared with the yellow Mississippi water. The explanation for this can be found in the color of the materials causing the turbidity, which give the Mississippi a brownish-yellow color as compared with the gray of the Ohio.

The lowest turbidity reported from any station in this study was in the Illinois River at Peoria; this undoubtedly is due to sedimentation in the lakes above Peoria.

The variation in the length of the periods in which certain limiting ranges of temperature and turbidity occur simultaneously shows that if the two properties of coldness and clearness are desired, the conditions at Molina would be similar to or slightly better than those at Peoria, and conditions at Quincy would be slightly less favorable than those at Peoria.

The unfavorable conditions that exist in the Ohio River at Cairo have not been anticipated.

General Remarks

The present study is far from complete, as can be seen from the diagrams. However, it presents a new method of approach and makes use of all the long-term data that could be obtained in Illinois. Very few waterworks keep daily records; the majority make only occasional readings, which are not suitable for such a study. The cities of Chester and Thebes have been making good measurements for the last two years, but these will have to be continued over a considerably longer period before they are of real value.

There are some water works outside the State of Illinois which may have the information necessary for our study, but this la not readily available to our State Water Survey. It may be noted that there are no water works between Moline, Illinois, and Minneapolis, Minnesota, which use Mississippi River water.

Summary

Data are presented on the temperature and turbidity of river water at six stations along the Illinois, Ohio and Mississippi Rivers. These data are analyzed to show the periods year by year in which certain limiting conditions exist, both as to temperature and turbidity respectively, and also to determine the correlation of these phenomena within certain limited ranges. The trend in temperature and turbidity variations along the Mississippi River is indicated, and comparative data are offered for all stations.

Table 1

Days river temperatu re is °F. and 'below.

		35	40	45	50	55	60	65	70	75	80	85	90
Cairo	Max.	65	111	135	157	194	227	243	286	308	364	365	366
	Min.	0	9	50	107	120	164	191	207	243	272	316	365
	Ave.	32.5	76.0	106.2	137.0	161.7	194.0	217.9	245.6	273.5	322.8	359.0	365.0
E. St. Louis	Max.	24	99	136	157	173	209	234	263	285	338	366	366
	Min.	0	55	98	114	134	172	204	231	243	292	337	365
	Ave.	4.3	81.6	119.8	133.3	. 157.3	185.0	216.3	242.8	261.1	306.7	355.4	365.2
Alton	Max.	85	123	137	169	184	223	242	272	286	346	366	366
	Min.	36	91	110	120	140	176	203	231	235	279	335	360
	Ave.	65.5	104.0	126.9	146.7	167.9	193.0	221.9	246.8	267.4	313.7	357.5	364.7
Quincy	Max.	95	129	155	175	189	233	260	283	304	353	366	366
	Min.	23	82	115	135	158	183	209	237	251	302	348	365
	Ave.	60.2	112.6	136.6	161.1	177.8	203.3	232.3	258.1	280.3	328.7	362.8	365.2
Mollne	Max.	128	147	165	184	207	234	262	283	314	357	365	365
	Min.	90	104	131	150	172	195	221	240	276	321	356	362
	Ave.	108.9	126.5	149.9	168.5	189.8	214.6	240.8	263.1	295.7	340.1	362.6	364.7
Peoria	Max.	91	132	148		195	236	261	283	321	360	366	
	Mln.	28	94	112	128	168	181	207	246	280	335	360	
	Ave.	68.8	110.8	132.9	157.4	182.3	209.8	236.1	264.2	298.5	344.5	364.2	
Missouri River, St.Louis Co.	Max.	64	108	139	157	183	218	242	275	288	341	366	366
	Min.	10	44	94	119	142	169	196	228	253	304	354	365
	Ave.	34.2,	87.0	118.4	141.6	164.7	192.0	217.5	247.3	269.1	323.2	360.6	365.3

Table 2

Days Turbidity is ppm. and below.

		25	50	75	100	200	300	400	500	600	700	
Cairo	Max.	29	89	129	186	301	332	345	357	365	366	
	Min.	0	0	0	4	142	193	241	286	308	317	1936-1945
	Ave.	5.0	17.4	51.2	104.5	210.1	255.5	289.1	312.4	326.1	334.9	incl.
E. St. Louis	Max.	43	94	209	252	320	340	348	352	356	359	
	Min.	0	7	32	90	148	199	233	256	275	289	1937-1945
	Ave.	21.4	51.1	92.3	131.4	202.2	253.3	289.7	309.0	322.2	331.7	incl.
Alton	Max.	45	169	223	258	348	355	359	360	362	366	
	Min.	0	2	22	76	153	207	258	296	309	315	1936-1945
	Ave.	21.2	60.2	97.6	141.5	248.9	296.3	320.3	335.8	344.1	348.6	incl.
Quincy	Max.	92	250	278	283	336	352	356	361	364	366	
	Min.	0	51	64	87	179	245	293	314	329	331	1929-1945
	Ave.	27.4	120.2	l6l.0	197.4	264.4	299.7	322.1	336.9	345.8	350.9	incl.
Moline	Max.	141	194	239	291	354	359	363	365	365	365	
	Min.	44	78	115	171	277	309	323	335	342	345	1935-1945
	Ave.	83.5	136.3	179.1	225.5	313.0	342.5	352.1	357.4	360.0	361.5	incl.
Peoria	Max.	191	305	332	343	356	365	366	366	366	366	
	Min.	102	212	241	270	327	353	357	359	363	363	1935-1944
	Ave.	151.6	242.2	276.8	299.1	346.2	358.7	363.0	364.3	365.0	365.0	incl.
Missouri River, St. Louis Co.	Max.	13	36	39	42	63	72	109	143	157	168	
	Min.	0	0-	0	0	1	9	24	42	59	66	1935-1945
	Ave.	2.6	7.3	10.0	14.1	27.5	42.6	59.2	80.2	99.1	117.0	incl.

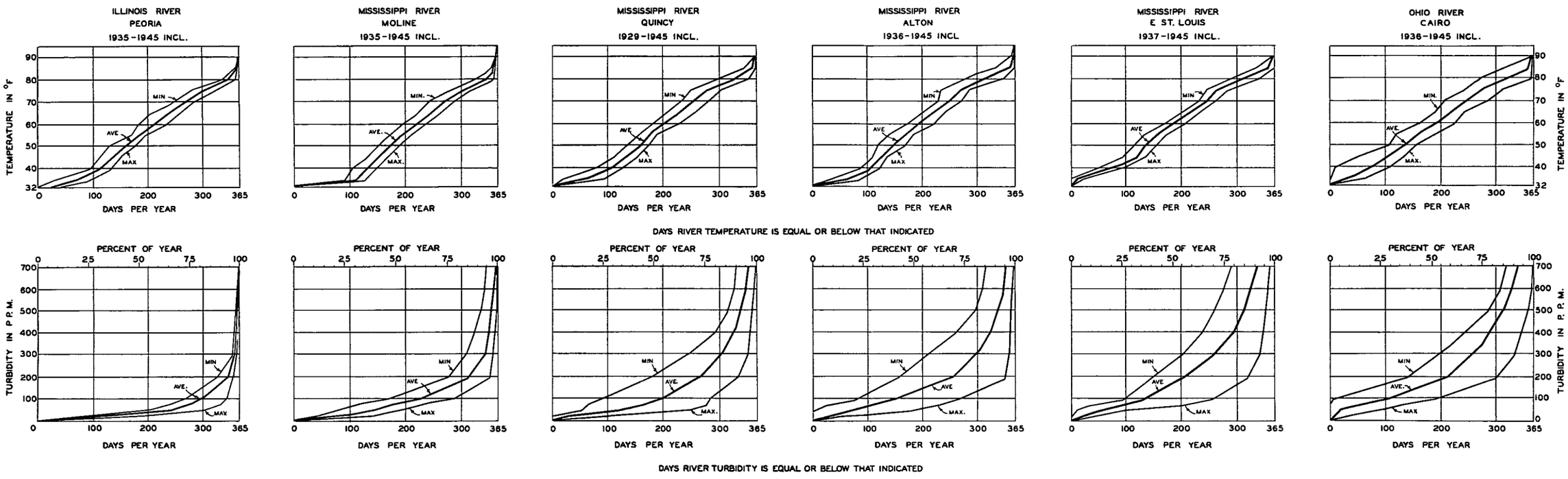
Table 3

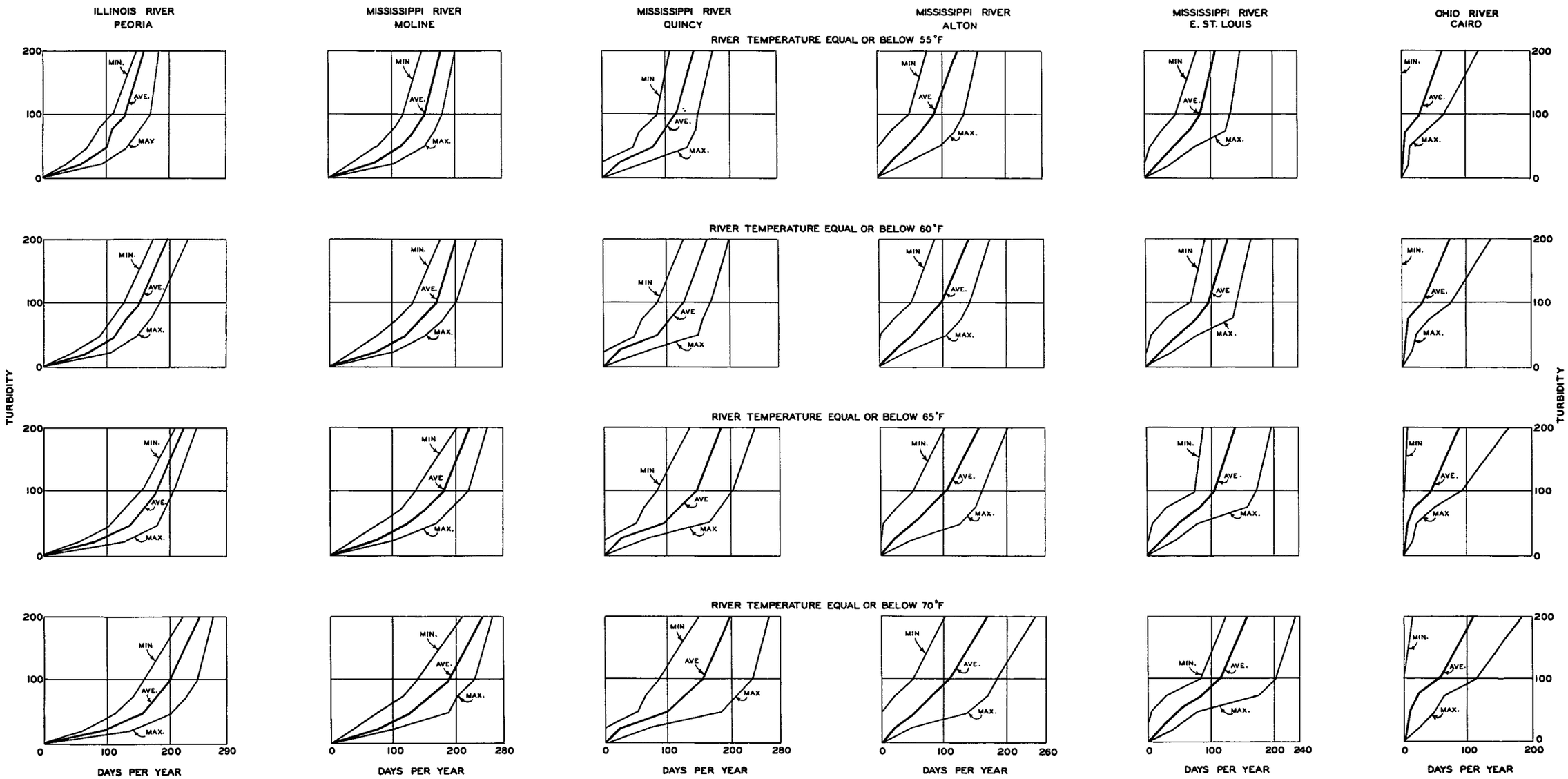
		Temp. ≤ 55°F.					Tamp. ≤ 60°F.				
Turb.	≤	25	50	75	100	200	25	50	75	100	200
Cairo	Max.	12	15	42	67	122	14	22	42	75	137
	Min.	0	0	0	0	1	0	0	0	0	2
	Ave.	2.0	2.7	9.1	27.9	62.4	2.2	3.5	10.0	32.3	73.0
E.St.Louie	Max.	43	76	127	133	147	43	78	133	139	161
	Min.	0	7	25	47	78	0	7	28	68	89
	Ave.	20.6	43.6	68.1	82.8	108.0	20.6	46.3	75.8	94.8	124.4
Alton	Max.	45	100	123	134	158	45	106	129	142	172
	Min.	0	2	22	48	77	0	2	22	49	85
	Ave.	19.7	47.6	70.0	89.4	123.8	19.7	48.2	72.2	96.5	139.6
Quincy	Max.	66	132	145	149	171	66	147	155	166	195
	Min.	0	50	59	84	106	0	50	60	84	127
	Ave.	24.7	81.1	98.6	115.5	142.5	25.0	87.8	108.3	128.1	161.5
Moline	Max.	104	149	164	176	200	104	150	177	195	227
	Min.	36	78	101	115	145	38	78	106	130	171
	Ave.	75.5	113.4	133.7	148.9	173.4	75.8	117.7	142.5	164.4	195.4
Peoria	Max.	96	132	149	168	182	108	145	164	180	223
	Min.	39	70	84	107	145	43	85	104	123	169
	Ave.	58.8	97.1	111.1	128.8	156.1	67.8	110.5	128.3	148.7	192.2

Table 3 (continued)

		Tenro. < 65°F.					Temp. ≤ 70°F.				
	Turb.<	25	50	75	100	200	25	50	75	100	200
Cairo	Max.	15	22	51	93	167	25	49	64	114	194
	Min.	0	0	0	0	5	0	0	0	0	15
	Ave.	3.2	6.2	15.0	42.5	87.9	4.2	9.3	22.2	54.6	109.8
E.St. Louie	Max.	43	78	156	169	192	43	78	174	201	231
	Min.	0	7	30	77	97	0	7	30	82	123
	Ave.	20.6	47.2	80.8	103.0	137.0	20.6	47.7	84.2	111.9	155.4
Alton	Max.	45	125	148	159	198	45	138	167	181	239
	Min.	0	2	22	49	98	0	2	22	49	99
	Ave.	19.7	50.1	76.1	101.8	152.1	19.7	51.4	79.3	107.2	167.0
Quincy	Max.	66	165	185	202	233	66	181	204	229	256
	Min.	0	50	64	84	137	0	50	64	84	148
	Ave.	25.0	93.3	119.9	144.4	181.9	25.4	98.8	127.2	153.9	197.4
Molina	Max.	104	169	184	217	248	104	185	200	225	255
	Min.	38	78	113	133	201	38	78	113	135	208
	Ave.	75.8	121.6	150.6	178.5	218.7	75.8	124.4	155.5	184.6	235.2
Peoria	Max.	129	176	187	203	238	135	197	222	240	266
	Min.	55	103	127	150	205	63	112	139	153	217
	Ave.	82.2	133.9	154.5	174.8	218.7	93.2	152.0	175.2	196.9	242.6

NOTE: Calculations for Missouri River not presented as turbidities were only during 2 to 3 years within range considered.


ILLINOIS RIVER
PEORIA
1935-1945 INCL.
MISSISSIPPI RIVER
MOLINE
1935-1945 INCL.
MISSISSIPPI RIVER
QUINCY
1929-1945 INCL.
MISSISSIPPI RIVER
ALTON
1936-1945 INCL
MISSISSIPPI RIVER
E ST. LOUIS
1937-1945 INCL.
OHIO RIVER
CAIRO
1936-1945 INCL.
TEMPERATURE IN °F
DAYS PER YEAR
MIN.
AVE.
MAX.
DAYS RIVER TEMPERATURE IS EQUAL OR BELOW THAT INDICATED
PERCENT OF YEAR
TURBIDITY IN P.P.M.
DAYS RIVER TURBIDITY IS EQUAL OR BELOW THAT INDICATED



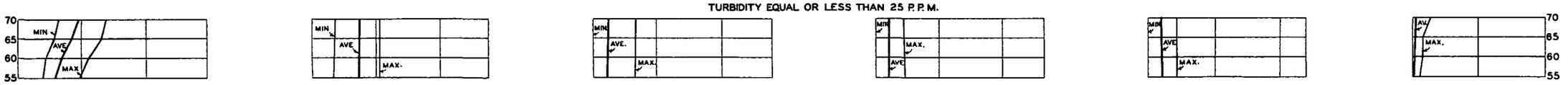
DAYS RIVER WATER IS AT CONDITIONS INDICATED WITH TEMPERATURE LIMIT CONSTANT

TURBIDITY IN PARTS PER MILLION OR LESS

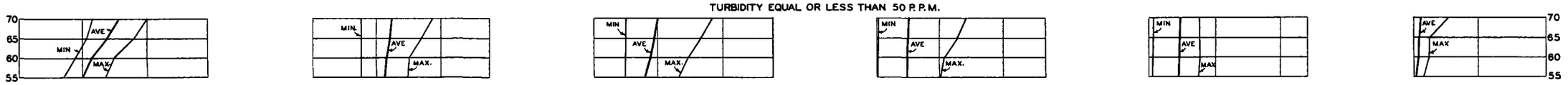
ILLINOIS STATE WATER SURVEY DIVISION

ILLINOIS RIVER PEORIA | MISSISSIPPI RIVER MOLINE | MISSISSIPPI RIVER QUINCY | MISSISSIPPI RIVER ALTON | MISSISSIPPI RIVER E. ST. LOUIS | OHIO RIVER CAIRO

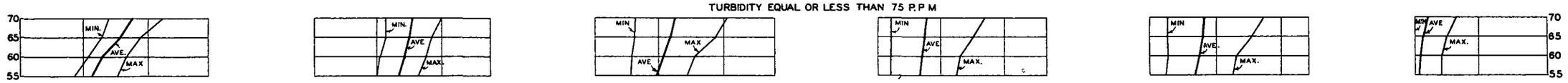
TURBIDITY EQUAL OR LESS THAN 25 P.P.M.



TURBIDITY EQUAL OR LESS THAN 50 P.P.M.



TURBIDITY EQUAL OR LESS THAN 75 P.P.M



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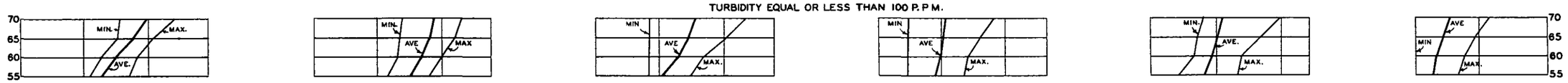

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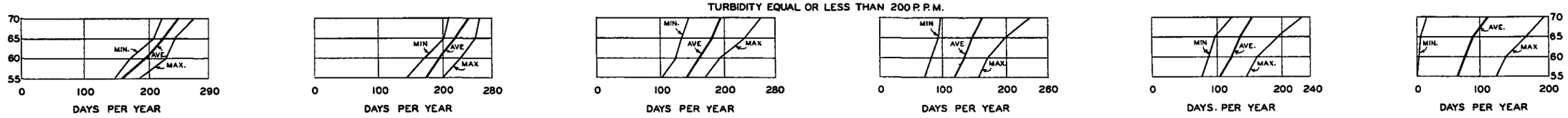
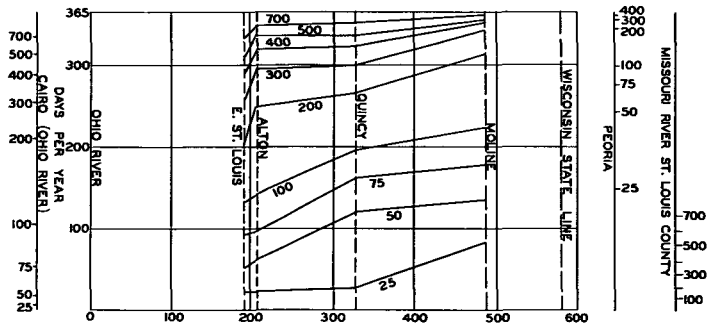


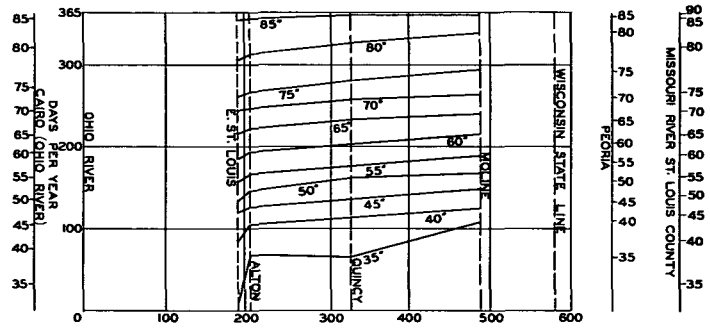
DAYS RIVER WATER IS AT CONDITIONS INDICATED WITH TURBIDITY LIMIT CONSTANT

°F OR BELOW

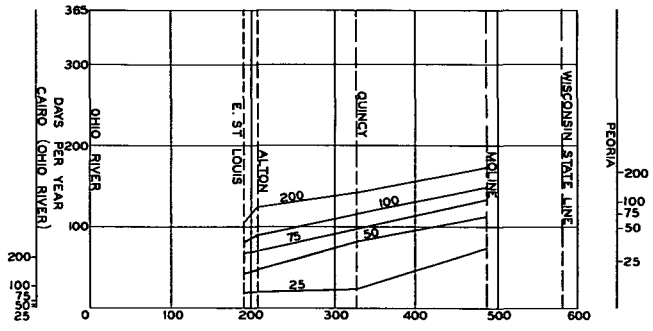
MISSISSIPPI RIVER



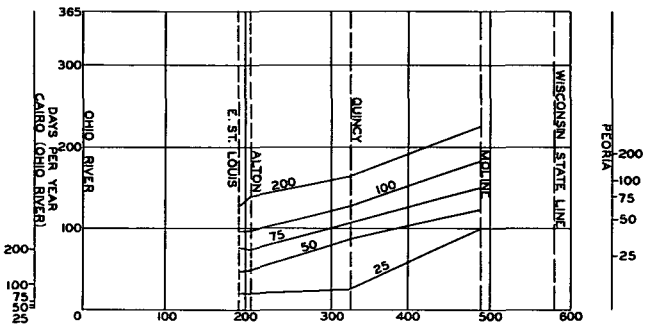
DAYS RIVER TURBIDITY IS EQUAL OR BELOW THAT INDICATED



DAYS RIVER TEMPERATURE IS EQUAL OR BELOW THAT INDICATED



DAYS RIVER TURBIDITY IS EQUAL OR BELOW THAT INDICATED
RIVER TEMPERATURE 55°F OR BELOW



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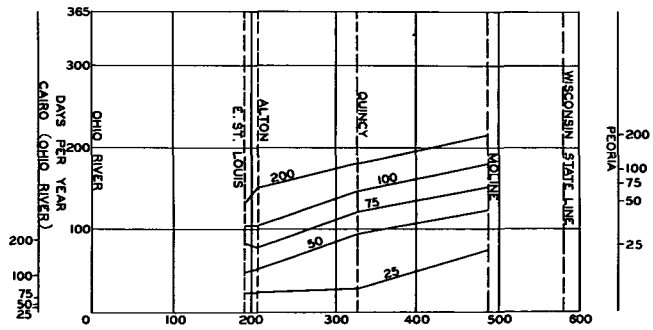
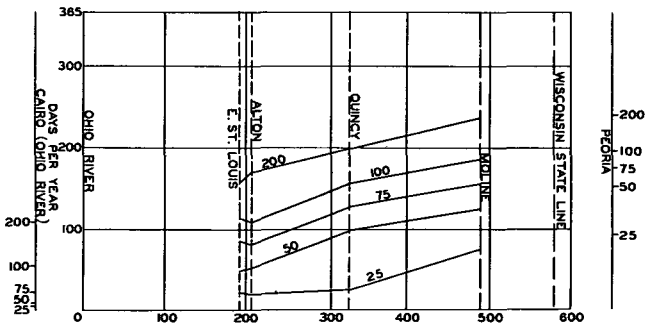
RIVER TEMPERATURE 60°F OR BELOW



DAYS RIVER TURBIDITY IS EQUAL OR BELOW THAT INDICATED
RIVER TEMPERATURE 65°F OR BELOW



DAYS RIVER TURBIDITY IS EQUAL OR BELOW THAT INDICATED
RIVER TEMPERATURE 70 °F OR BELOW

TEMPERATURE IN °F
TURBIDITY IN PARTS PER MILLION